MOUNT BAKER BRIDGE TUNNEL
Interstate 90, passing under Mount Baker Bridge
Seattle
King County
Washington

HAER No. WA-109

HAER
WASH
17-SEAT
15-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Department of the Interior
P.O. Box 37127
Washington, D.C. 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

MOUNT BAKER RIDGE TUNNEL

HAER No. WA-109

Location:	Interstate 90, passing under Mount Baker Ridge, .8 miles east of the junction with State Route 900, Seattle, King County, Washington, beginning at mile point 3.82. UTM: 10/553590/5270780 10/553140/5270780 Quad: Seattle South, Wash.
Date of Construction:	1940
Date of Rehabilitation:	1993
Engineer:	Washington Department of Highways
Fabricator:	Bates and Rogers Construction Corporation, Chicago.
Owner:	Washington Toll Bridge Authority, later Washington Department of Highways. From 1977, Washington State Department of Transportation, Olympia, Washington.
Present Use:	Vehicular traffic. No pedestrian traffic in the old bores since rehabilitation.
Significance:	In the context of Western tunneling, it is remarkable for both the material it was driven through (clay), and the form it took (twin bore). It ranks as the worlds's largest diameter soft earth tunnel. The highly stylized treatment of the east portal demonstrates the way in which Modernistic Architecture was applied to engineering structures. It was a part of the Lake Washington Floating Bridge/Lacey V. Murrow Memorial Bridge (HAER No. WA-2) project.
Historian:	Jonathan Clarke, August 1993.

History of the Bridge

The Mount Baker Ridge Tunnel was built as an essential component of the Lake Washington Floating Bridge, a massive program designed to provide a shorter link between the east side of Lake Washington and Seattle. Eastward from Seattle, the new routeway was designed to connect with the Snoqualmie Pass Highway, a heavily used traffic artery crossing the Cascade Mountains from the eastern part of the state. The bridge's construction was tremendously important, locally, regionally and nationally. Lake Washington had formerly presented a barrier for the residents of Mercer Island and the east shore district from reaching Seattle quickly and easily. It had also blocked access to commercial traffic entering Seattle--the principal seaport city on the Pacific Northwest and the U.S. Gateway to Alaska and the Far East from the east. Its completion signified a new era of commercial growth and opportunity for the city. It was in recognition of this that the east portal of the tunnel--the westernmost structural component of the whole project and the entranceway into the heart of the city--was elaborately designed to announce the "City of Seattle," as "Portal of the North Pacific", "The Orient" and "Alaska."[1]

The idea for the project came as early as 1920, when Homer M. Hadley, engineer in the Seattle school Architect's office began preliminary investigations into the feasibility of constructing a reinforced concrete pontoon bridge across Lake Washington. This was to be but one element in a proposed route linking the existing Sunset Highway at a point near North Bend to the center of Seattle. The route however was blocked by one of Seattle's seven Hills, the Mount Baker Ridge, which rises abruptly from sea level from the west shore of Lake Washington to an elevation of 260'. Clearly the mastery of this obstacle was crucial to the realization of the whole project. Yet the siting of this throughway was equally critical, because of the anticipated expense of constructing the approach to the floating bridge. Hadley selected the narrowest place of the ridge for a tunnel, where the ridge dropped particularly steeply on the western side. This was later to be the exact spot where the tunnel was eventually built.[2]

It was to take until 1937 before the Lake Washington Floating Bridge was given serious consideration. Hadley had failed to attract financial backing for his ideas, largely on account of his inexperience and association with the Portland Cement Association, and it was not until this time that widespread public and official agitation for the said route arose. Early in 1937 the Washington Toll Bridge Authority was created by the legislature, and in that summer was requested by the Board of King County Commissioners to investigate the most feasible route and type of structure across Lake Washington. Under the direction of Lacey V. Murrow, Chief Engineer of the Toll Bridge Authority, a number of potential routes were evaluated. The most advantageous in terms of directness, grade, cost, and accessibility to both local and state traffic was found to be Hadley's. It was to run eastward along Atlantic Street from Rainier Avenue in Seattle, through a tunnel in the Mount Baker Ridge, across the lake via a pontoon bridge with fixed shore spans, across Mercer Island, then across the easterly arm of the lake before finally terminating in Issaquah. A highway over the ridge was ruled out on account of the excessive grades it would have involved, disrupting the free flow of traffic.[3]

A project of such immense undertaking, requiring the construction of approach roadways, bridges, tunnels, and grade separation structures in addition to the floating portion crossing the main channel of the lake, clearly posed problems in terms of the coordination and administration of the different components. For this reason, the entire project, some 6-1/2 miles in length, was organized into 11 separate units, each let under its own separate contract. Contract No. 2 entailed the construction of a vehicular tunnel under Mount Baker Ridge, as well as the grading, draining, paving and electric lighting of the connecting roads and highway at either end of the tunnels. The limit of work was defined to the east by the end of unit number 1 at 27th Avenue South, and to the west by the start of contract No. 3, the fixed approach to the floating bridge on the west side of Lake Washington. Unit bids for this unit appeared in the February 1939 issue of *Western Construction News*. The contract was awarded to Bates and Rogers Construction Corporation of Chicago for $1,372,320.11, an amount second only to the cost of constructing the concrete pontoon bridge itself.[4]

The original plans called for a single bore tunnel, but these were subsequently upgraded to include two separate traffic lanes and a pedestrian sidewalk.[5] Once these were finalized, work on the twin tunnels was able to commence from the east end. Initial progress was slow however, hampered by a 115-day delay caused by right-of-way proceedings. By late January 1940 the construction firms were forced to demand contractual adjustments if the July 1 deadline was to be made, and Lacey Murrow, on behalf of the Washington Toll Bridge Authority, was obliged to present an additional $30,000 for the purchase of additional machinery so that work could begin on the west end of the bores. Originally it had been intended that boring would continue all the way through the ridge from the east end.[6]

Throughout most its construction, the Mount Baker Ridge Tunnel and the other less showy components of the project seem to have been overshadowed by the building of the actual pontoon bridge. This novel, seemingly implausible piece of engineering frequently elicited the curiosity and wonder of hundreds of spectators who watched from the shores, and more often than not generated the majority of local media interest. Yet when on 25 January 1940 the Toll Bridge Authority announced adoption of plans for the architectural treatment of the east portal, the situation was remedied somewhat. Described as "strikingly beautiful" in one newspaper, it was this portal, floodlit at night, that transformed what was perhaps to most people just another engineering structure into a magnificent, monumental entranceway into the city.[7]

Design and Description

The Mount Baker Ridge Tunnel consists of two identical concrete lined tunnels, each 1,466' long and spaced 60' apart from center to center, and adorned at either end by massive, embellished concrete portals. Each carries a 24' roadway and a 3' sidewalk, enabling one way vehicular and pedestrian traffic to pass in each direction. Either tunnel is of a modified horseshoe cross-section, with the invert backfilled to the grade of the concrete road paving slab. The vertical clearance between the crown of the paving and the arch of the roof is 23', whilst that between the curb line and the roof is 14'-6".[8]

Both east and west portal façades are massive and imposing. The façade of the east tunnel portal is tiered in a series of three setbacks, a Modernistic or Art Deco reinterpretation of a Gothic semi-circular arch. A plaza area just east of east portal affords viewing of both the portal and Lake Washington.

Three precast low-relief sculptured panels, each 22-1/2' in height and 11' in width adorn the east portal façade; one on either side of each arch and the other centrally disposed between them. The central panel bears the words "City of Seattle Portal of the North Pacific", whilst either of the flanking panels carries the words "The Orient" and "Alaska" respectively. All effectively depict artistic or cultural motifs: a highly stylised sperm whale, an oriental dragon, and Northwest Coast Indian symbolism respectively. The impressive architectural treatment given to the entrance is the product of the collaboration of engineer Lloyd Lovegren, of the Washington State Highways Department, and artist James Fitzgerald.[9]

The specialized nature of the material making up the Mount Baker Ridge influenced both the tunnel's form and the construction methods used to bore the tunnel. It consisted of a tight, heavy blue clay of glacial origin, with a 28 to 35 percent water content, and a variable consistency ranging from fairly dry, lumpy structure to a wet, slippery material. It was one factor in determining the selection of the twin bore type of tunnel; it also helped dictate that a horseshoe type or circular section bore be used. Tunneling through hard rock is usually performed using a semi-circular arch section with vertical side walls. However, where cohesionless or plastic materials, such as clay, are to be bored, a circular section or horseshoe section is used. Both of these, although the former especially, are able to resist, through arch action, the far greater pressure in all directions that is a feature this type of material. The selection of a horseshoe section and invert for the Mount Baker Ridge represented a compromise between the straight sided semi-circular arch, and the circular section, having the advantage of both strength and greater available working space afforded by the flat bottom or invert.[10]

The plasticity of the material, and the absence of any rock, enabled the boring to be accomplished without recourse to drilling or explosives: all mucking was undertaken using compressed air tools and electric shovels. However, the enormous pressures exerted by the wet clay, especially underneath the top of the ridge where the depth was some 125', required that extremely heavy timbering was used throughout the operation. It was these aforementioned features that made the tunnel significant from a structural perspective. Indeed, the driving of tunnels through blue clay was unusual in the western United States, and for that reason *Western Construction News* acknowledged the "special place in the history of western tunneling" that the bores through Mount Baker Ridge secured.[11]

The first stage in the construction process was the excavation of some 55,000 cubic yards of material from the east side of the ridge, forming a steeply inclined face from which to advance the tunnels. This muck was heaped in the view plaza adjacent to the east portal.[12]

Once the portal cut was completed, the initial tunneling operation was able to begin. Both tunnels were driven simultaneously and much the same methods were used for each. A crown heading or drift 9' x 8' cross-section was hand-driven by pneumatic air spades, the waste being shoveled into wheelbarrows which were then emptied beside the portal. As this tunnel advanced, the function of which was to make the roof safe before the bulk excavation, it was supported at 6' intervals by 10" x 10" timber sets. Two wall-plate drifts of approximately the same section were then driven in on either side of the floor of the tunnel, following the crown drift by some 20'. These too were driven by air spades and hand shoveling, and were supported with temporary timbering. When this was completed, permanent 12" x 16" timber wall plates were installed. In soft ground tunneling they provided necessary support for the relatively cohesionless material, which will not withstand permanent support from timber or steel sets alone.[13]

Coming after this operation, the three advance headings were connected, so forming the arch ring. Timbering, in seven segments was then set along the arch. With this completed, the excavation was extended down the sides as far as grade so that plumb posts could be set to support the wall plates against the central core of the tunnel.[14]

With the completion of the temporary supporting system, excavation of the core could proceed. This was done using electric shovels, one in each tunnel, which loaded the material into 4- or 5-yard size dump cars. These cars were transported by electric locomotives, running along rail tracks laid behind the advancing face of the core.[15]

Some 150' behind the removal of the core, the concrete tunnel lining operation followed. These two operations were deliberately kept in close proximity in order to avoid the problems of resisting the crushing pressure with temporary timbering. Indeed, the pressures which the clay exerted on the arch timbering were so immense that in some places the adjacent 10" thick wall plates were compressed to half their width.

The lining equipment comprised of a wooden jumbo and a travelling steel arch form. Two continuous footing blocks were poured first, ahead of the lining section, using wooden forms which were removed and reset. A horizontal step was cast on the surface of the footings to place rails which in turn would carry the jumbo and steel arch form. The jumbos, one in each tunnel, were then moved forward so that timber lagging could be removed and reinforcing steel placed. Following closely, the steel arch form was moved forward in 32' lengths of pour. This was carefully adjusted into place for line and grade by screwjacks operating both horizontally and vertically. A three foot pneumatic gun was then used to shoot concrete behind the forms, each 32' lengths of pour taking about 60 hours of continuous placing. The concrete was vibrated by mechanical air vibrators attached to the outside of the steel forms; the forms being left in place until the concrete attained a breaking stress of 600 pounds per square inch (psi). This was determined experimentally to take approximately 40 hours. The specified strength of the concrete at 28 days was 3,400 psi.[16]

After one 32' section of lining was complete to this specification, the jacks were used to lower the arch form which was then moved ahead and repositioned for the next pour. All the lining was thoroughly reinforced with steel bars, having a diameter for the most part of 3/4", and running in two parallel rows at variable spacing. The inside row of 3/4" round bars varied from a minimum 12" spacing to a maximum of 6" spacing. The outer row varied from three 3/4" round bars between the timbers, to a maximum of three 3/4" and for 7/8" bars in the rib sections between the timbers.[17]

Following behind the completion of the arch lining the invert was removed so that the lower curved section between the footings could be poured. The concrete was poured to a thickness of 24", covering the reinforcing rods that extended from the wall sections. This operation, unlike those preceeding it, did not follow in a regular movement forwards. It was applied first to those sections where the pressure from the overburden was greatest in order to expedite the completion of the particular tunnel unit. After the entire length of this section of the lining had been poured, the invert was back-filled to the paving grade so that 8" concrete roadway slabs could be laid. The final construction work included the paving of the sidewalk, the installation of a pedestrian railing, and the pouring of the east and west portals.[18]

Two major field problems arose during the course of construction. Immediately following the placement of the initial arch timbering at the entrance to the tunnel, the hill directly above the portal began to slump, pushing the timbering out of line and downwards so that there was insufficient clearance. This necessitated the placing of cross timber across the mouth of the tunnel and bracing this with 18" x 18" timbers supported by concrete anchors resting on the ground some 40' forwards from the tunnel. Also, steel ring sets were used to replace some of the arch timbers which were deformed or misaligned to the extent where they would have prevented a sufficient thickness of concrete to be poured.

A similar situation arose when it was decided, against original plans, to commence tunneling from the west end also. The hill began moving even before tunneling began, rendering the portal face too unstable to begin work in the usual fashion. Accordingly, a crib was driven into the face, enabling a 20' section at a time to be open cut, until, at a distance of 60', the clay was solid enough to bear tunneling. To safeguard against misalignment of the ring sets in this section, tie rods were placed between each successive set for a distance of some 400' into the tunnel.[19]

Each tunnel, when completed was equipped with three equally spaced air ducts, the shaft of which extended to a common vent at the top of the hill some 110' above the roadway level. Each was illuminated day and night by 10,000-lumen sodium vapor lights spaced at 80' intervals. In addition, near either portal, 16,000-lumen mercury vapor lights were employed to operate during the day only, enabling motorists to accustom themselves more easily to the relative dimness of the tunnels.[20] To this day the Mount Baker Ridge Tunnel remains unchallenged as the worlds's largest diameter soft earth tunnel.[21]

Maintenance

Both tunnel bores have remained in good overall condition since their construction. From 1960 until 1982, water seepage through the concrete lining joints was listed on virtually every yearly/bi-yearly report. The problem was more pronounced in the north bore, especially concentrated towards the entrance and exit. By 1974 some leaching cracks were noticed on the actual portals. The high ground water table resulting from prolonged rainfall in the spring of 1960 seems to have precipitated the leaching. However, for the entire period 1949 to 1960 Washington Washington Department of Highways bridge inspectors recommended no repairs.[22]

A Washington State Department of Transportation Historic Bridge Inventory notes that recently, extensive modifications have been made to the tunnel. These include the removal of the west portal and its replacement with a new retaining wall, the attachment of precast concrete walls with ceramic facing to the sides of the original liner, and the installation of duct walls between the ceiling and the top of the liner, forming an exhaust air duct and supply air duct. The alterations were completed in 1993 and in all likelihood they accompanied the (on-going) reconditioning of the pontoon bridge. A discussion held on 17 March 1993 concluded that these changes did not threaten the structure's National Register of Historic Places status, because the primary element considered for register elegibility was the decorative east portal, and this remains unaffected.[23]

Data Limitations

The engineering articles describing both this structure, and The Lake Washington Bridge Project were cited in the *Engineering Index*. Both journals are available at the University of Washington, Seattle. The Historical Society of Seattle and King County, Seattle, have a copy of the official dedication booklet, which provided some technical information. A particularly important information source for the tunnel is the monthly progress reports for Lake Washington Bridge Project, held at the Washington State Department of Transportation Library in Olympia. Essentially a (large format) photographic record of this, it clearly conveys the enormity and importance of the project.

The major deficiency with regard to information was a lack of newspaper articles; almost all refer to the construction of the bridge. A scrap book in the local history section of the Seattle Public Library yielded some, mostly non-sourced/dated articles, however (see bibliography).

Project Information

This project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States.

The Washington State Historic Bridges Recording Project was co-sponsored in 1993 by HAER, the Washington State Department of Transportation (WSDOT), and the Washington State Office of Archeology & Historic Preservation. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Robert J. Kapsch, Ph.D., Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; and Dean Herrin, Ph.D., HAER Staff Historian.

The recording team consisted of Karl W. Stumpf, Supervisory Architect (University of Illinois at Urbana-Champaign); Robert W. Hadlow, Ph.D., Supervisory Historian (Washington State University); Vivian Chi (University of Maryland); Erin M. Doherty (Miami University), Catherine I. Kudlik (The Catholic University of America), and Wolfgang G. Mayr (U.S./International Council on Monuments and Sites/Technical University of Vienna), Architectural Technicians; Jonathan Clarke (ICOMOS/Ironbridge Institute, England) and Wm. Michael Lawrence (University of Illinois at Urbana-Champaign), Historians; and Jet Lowe (Washington, D.C.), HAER Photographer.

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ENDNOTES

[1] "Lake Washington Floating Bridge, Seattle, Washington," Official Dedication Booklet; and Washington Toll Bridge Authority, "Lake Washington Bridge Seattle," both held by Washington State Department of Transportation Library, Olympia, WA; Lacey V. Murrow, "Early History of the Lake Washington Floating Bridge," *Pacific Builder and Engineer* 46 (5 October 1940): 46.

[2] Lucille McDonald, "The Inspiration For the First Floating Bridge," *Seattle Times*, 26 July 1964, 6; Harold V. Judd, "Twin Bore Tunnels: Construction methods used to bore 30' tunnels through the glacial blue clay of Mount Baker Ridge," *Pacific Builder and Engineer*, n.d.

[3] Murrow, "Early History of the Lake Washington Floating Bridge," 46; Judd, "Twin Bore Tunnels: Construction methods used to bore 30' tunnels through the glacial blue clay of Mount Baker Ridge," n.p.; McDonald, "The Inspiration For the First Floating Bridge," 6.

[4] "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," *Western Construction News* 15 (July 1940): 246; E. H. Thomas, "Approaches to Lake Washington Bridge," *Pacific Builder and Engineer*, n.d.

[5] "Work Begins on City Tunnel" *Seattle Daily Times*, in G. S. Castello's Scrapbook on Alaska, Seattle, and Washington, vol. 6, held by Local History Section, Seattle Public Library, Seattle, WA.

[6] "Additional $30,000 Allowed for Completion of Lake Bridge Tunnel." G. S. Castello's Scrapbook on Alaska, Seattle, and Washington, vol. 6, p. 66, held by the Local History Section, Seattle Public Library, Seattle, WA.

[7] Ibid.; [Soderberg, Lisa] "HAER Inventory/Mount Baker Ridge Tunnel [1980], held by Washington State Office of Archaeology and Historic Preservation.

[8] Judd, "Twin Bore Tunnels: Construction Methods Used to Bore 30' Tunnels Through the Glacial Blue Clay of Mount Baker Ridge," n.d.; "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," 246; "Lake Washington Floating Bridge, Seattle, Washington," Official Dedication Booklet; Washington Toll Bridge Authority, "Lake Washington Bridge Seattle."

[9] "Monumental Hazard," *Mercer Island Reporter*, 17 February 1977.

[10] Rush T. Sill, "Modern Tunneling Practice," *Western Construction*, December 1951, 67; "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," 246.

[11] "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," 246.

[12] Judd, "Twin Bore Tunnels: Construction Methods Used to Bore 30' Tunnels Through the Glacial Blue Clay of Mount Baker Ridge," n.d.

[13] "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," 247; Judd, "Twin Bore Tunnels: Construction Methods Used to Bore 30' Tunnels Through the Glacial Blue Clay of Mount Baker Ridge," n.d.; "'Pay Dirt' Struck In Lake Tunnel," G. S. Castello's Scrapbook on Alaska, Seattle, and Washington, vol. 6, held by the Local History Section, Seattle Public Library, Seattle, WA.

[14] "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," 247.

[15] Ibid., 248.

[16] Ibid., 246-249; Judd, "Twin Bore Tunnels: Construction Methods Used to Bore 30' Tunnels Through the Glacial Blue Clay of Mount Baker Ridge," n.d.

[17] "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," 249.

[18] Ibid.

[19] E. H. Thomas, "Approaches to Lake Washington Bridge," *Pacific Builder and Engineer*, n.d.

[20] "Twin Tunnels Driven Through Clay For Lake Washington Bridge Project," 249.

[21] This assertion was made on the reverse of a recent postcard of the Lake Washington floating bridge, and needs to be verified in the *Guiness Book of Records*.

[22] "Mount Baker Ridge Tunnel, No. 90/24," Bridge Inspection Reports (1947-1981) in Correspondence Files; and "Mount Baker Ridge Tunnel No. 90/24," Kardex Card File, both held by Bridge Preservation Section, WSDOT, Olympia, WA.

[23] WSDOT Historic Bridge Inventory--"Mount Baker Ridge Tunnel, No. 90/24," held by Environmental Unit, WSDOT.